Note on the Mass of Saturn. By Prof. Asaph Hall.

(*Communicated by Rear-Admiral R. W. Shufeldt, Supt. of Naval Observatory.*)

At the beginning of my observations with the 26-inch Equatorial at Washington in 1875, the apparent difference of declination of *Iapetus*, the outer satellite of *Saturn*, and the planet was very small. It occurred to me that it would be well to observe the difference of Right Ascension and Declination of the planet and satellite, since the mean distance of the satellite would be determined chiefly from the difference of Right Ascension, and so would not depend essentially on the assumed value of a revolution of the micrometer screw. *Iapetus* was observed therefore in this manner in 1875, 1876, and 1877. The differences of Right Ascension were observed as carefully as possible on a chronograph. In 1875 each difference of Right Ascension depends on about twenty-five transits, and in the other years on about twenty transits. The average probable error of a single difference of Right Ascension is $\pm 0^{s}.044$. Both limbs of *Saturn* were observed; and in every year the satellite was observed in both positions, preceding and following the planet. Each difference of Declination depends on five bisections of the planet and satellite.

The observed differences of Right Ascension and Declination correspond to what Bessel denotes as x and y in his work on the orbit of *Titan* (*Astronomische Nachrichten*, Band 9); and the equations of condition are formed very conveniently by means of Bessel's formulæ. The equations for each year have been treated separately, since the periodical perturbations of this satellite produced by the Sun are quite large. The solution of the equations of condition by the method of least squares gives the following values of the mean distance of *Iapetus* from *Saturn* at the distance 9·53885.

1875	$a = 515''.594 \pm 0''.056$	57 observations.
1876	$a = 515.454 \pm 0.058$	40 "
1877	$a = 515.517 \pm 0.053$	31 "
Mean	$a = 515.522$	128 "

The following table shows the number of equations of condition for each year; the sum of the squares of the independent terms before solution, the sum of the squares of the residuals after solution, first by elimination, and again by substitution; the maximum residual left in the equations after substitution, and the probable error of a single equation.

Year.	No of Equat.	$[nn]$	$[nn.6]$	$\Sigma.\nu^2$	Max. Residual	$r,$
1875	109	172''.274	27''.136	27''.095	1''.49	± 0''.346
1876	78	107.453	15.806	15.803	1.31	± 0.316
1877	61	110.935	8.336	8.324	1.26	± 0.263

The values of the mean distance for the different years agree so nearly that it is doubtful, I think, if the same observer can get a better determination of this quantity by this method. Should this mean value prove to be erroneous, then the error must exist in the method employed or in the observer, since the accidental errors seem to be nearly eliminated. The known variability in the brightness of this satellite when on different sides of the planet does not appear to have had any sensible influence on the result.

I have also a series of angles of position and distances observed with the filar micrometer, but the equations for these have not yet been formed.

In order to determine the periodic time of *Iapetus*, I have examined the old observations of this satellite, most of which, however, are of a very unsatisfactory character. A long series of observations made at Marseilles in 1787 by Bernard promised a good determination of the orbit at that date, and such a determination would be valuable, since in this way we could find from the observations the secular variation of the node and the periodic time of the satellite; but after a good deal of labour and many trials I have not been able to understand these observations. Lalande's interpretation of them is probably wrong, since he gets the inclination of the orbit largely in error (*Mém. de l'Académie*, Paris 1786). For the periodic time, therefore, I have used an observation by Sir William Herschel, Sept. 20, 1789, and the observations made by Sir John Herschel at the Cape of Good Hope in 1837. These have been compared with my own observed times of the conjunctions in 1880 and 1881. The adopted value of the sidereal revolution is

$$\text{Periodic Time} = 79{\cdot}3310152 \text{ days.}$$

Combining the above mean distance with this period we have data for determining the mass of *Saturn*. For *Saturn* I find

$$\rho - \tfrac{1}{2}\phi = 0{\cdot}01818,$$

and in the case of *Iapetus*, which is so distant from its primary, I have assumed that the factor

$$1 + \frac{\beta^2}{a^2}(\rho - \tfrac{1}{2}\phi)$$

is unity, this factor being the constant part of the expression, *Méc. Cél.* tome ii. p. 103. The masses of the satellites are unknown, and I have neglected the action of the Ring, since Bessel's value of its mass does not appear to be beyond question. We have therefore for the mass of the planet in units of the Sun's mass—

$$\text{Mass of Saturn} = \frac{1}{3482{\cdot}2}.$$

There is a series of observations of this satellite by Bessel in the volumes of the *Königsberg Observations*, 1832 to 1837. *Iapetus* was compared with *Titan* by means of the Heliometer; and it would be interesting to have a determination of the orbit of *Iapetus*, and of the mass of the planet, from these measures after the method proposed by O. Struve.

Naval Observatory, Washington:
1883, *Sept.* 25.

The Disappearance of the Satellites of Jupiter.
By Wentworth Erck.

The simultaneous disappearance, predicted by the *Nautical Almanac* for the morning of the 15th, did not take place, owing to an error of twenty-four minutes in the *Nautical Almanac* time of egress of the fourth satellite, which passed off the disk just as the third satellite entered on the disk.

The following is an abstract of the notes made on the occasion with a $7\frac{1}{2}$-in. Equatorial, and powers of 100 and 250.

G.M.T. 1883, *Oct.* 14.

12	42	±	I. disappeared, being eclipsed.
13	5	0	Shadows of II. and III. conspicuous; but cannot see Sat. IV., which is on the disk.
	51	15	II. about to enter on the disk.
14	14	12	III. shadow off the disk.
	21	10	II. on the very point of entering; its disk is well defined, as is that of III., but the disk of II. is apparently not more than one-third of the diameter of that of III.
	28	10	II. has now completely entered. Though II. and IV. are on the disk, and the definition good, yet I cannot see the satellites themselves with powers of 100 and 250.
15	36	0	II. shadow off disk.
	50	55	III. first contact with limb.
	50	55	IV. off the disk, at the same moment that III. makes contact at the opposite side of the disk; III. enters on the great Southern Belt, whereas IV. emerges at a point very far S. of the Belt at latitude, perhaps, 30°.
	56	0	III. half on; IV. well of.
	59	25	III. completely on, took about 8^m to enter.
16	13	50	I. re-appearing from occultation.
	15	50	I. completely off. III. not seen on disk.
	20	0	Observations discontinued.